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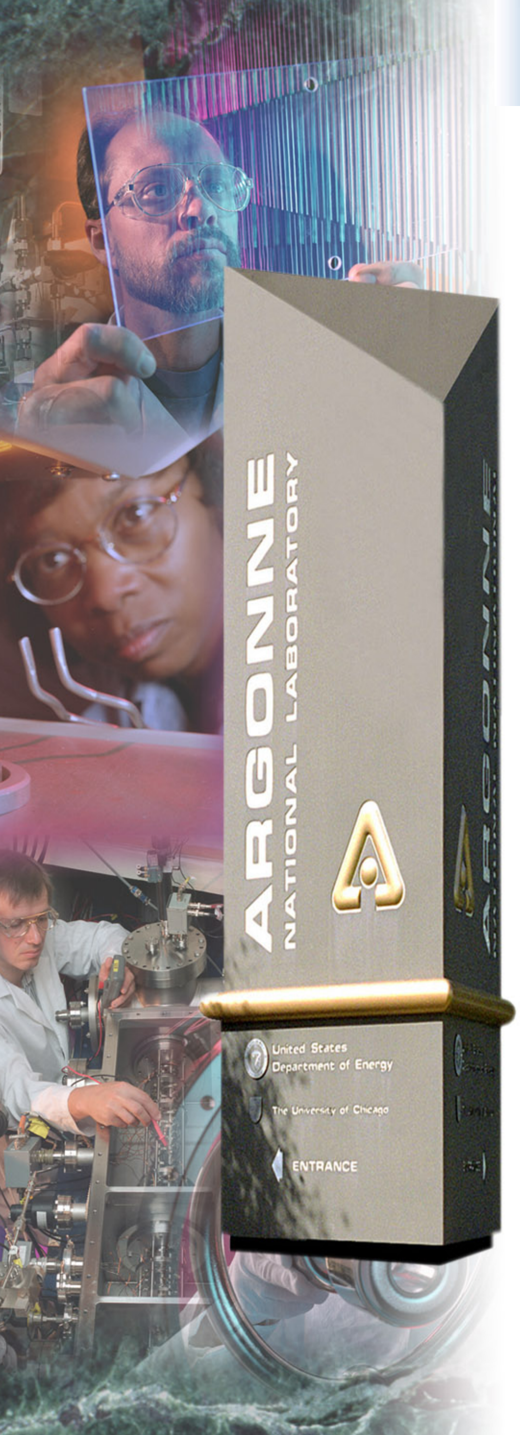

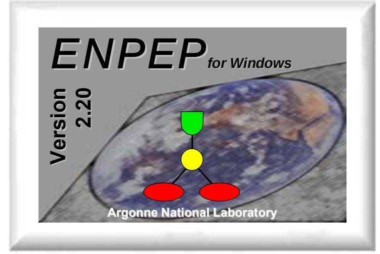

Overview of the Energy and Power Evaluation Program (ENPEP-BALANCE)

Guenter Conzelmann

Center for Energy, Environmental, and Economic Systems Analysis (CEEESA)
Decision and Information Sciences Division (DIS)
Argonne National Laboratory
9700 South Cass Avenue
Argonne, IL 60439
(ph) ++1-630-252-7173 (fax) ++1-630-252-6073
(email) guenter@anl.gov (web) www.ceeesa.anl.gov

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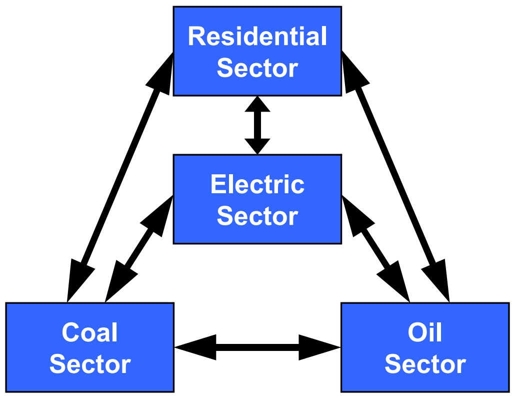
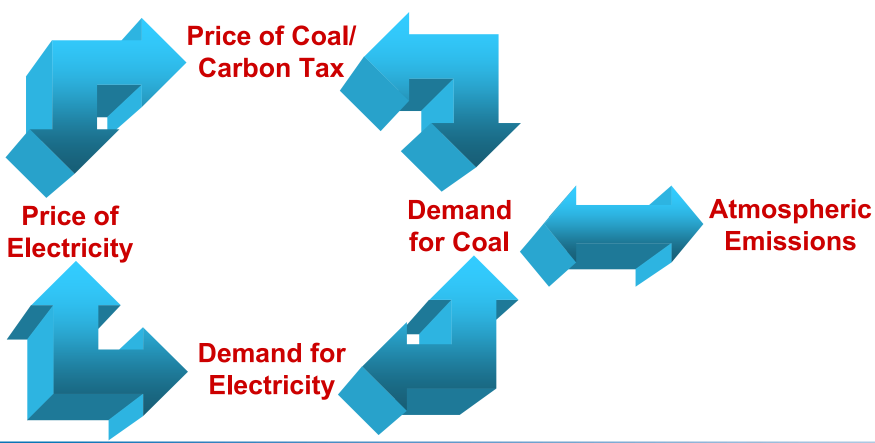
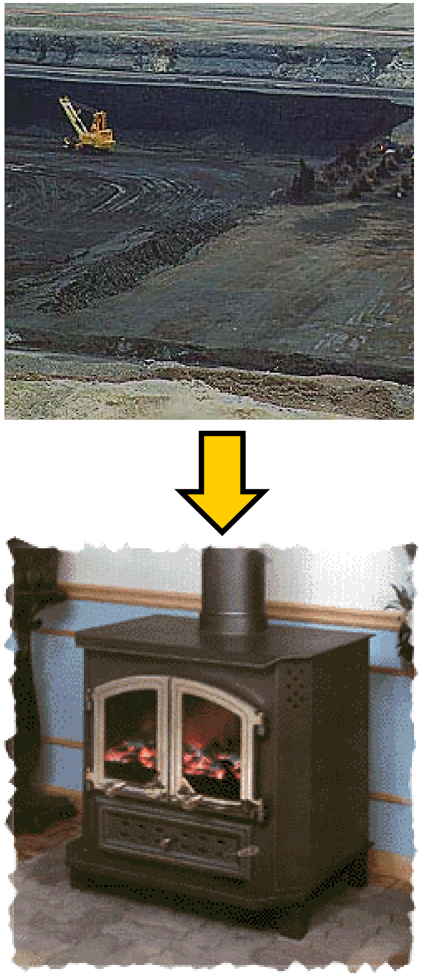
ENPEP-BALANCE is Designed to Analyze the Entire Energy System in an Integrated Framework

- Reveal cross-sectoral effects; provide structure for consistent energy “planning” program
- Integrated framework allows evaluation of feedback effects





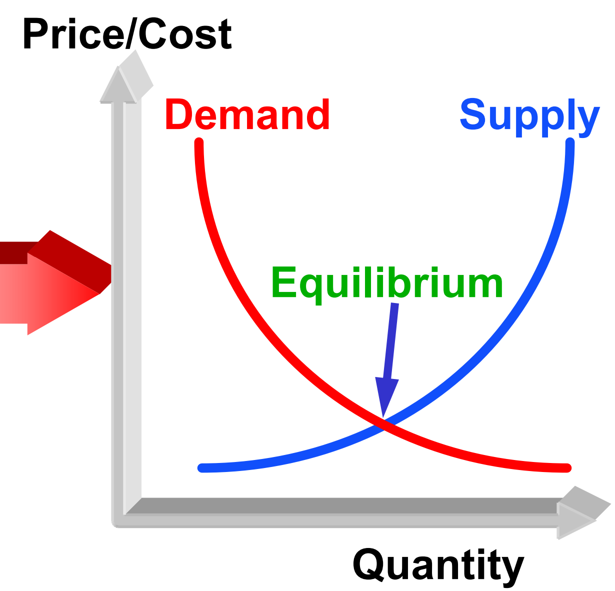


ENPEP-BALANCE Determines the Equilibrium Supply/Demand Balance of the Energy System

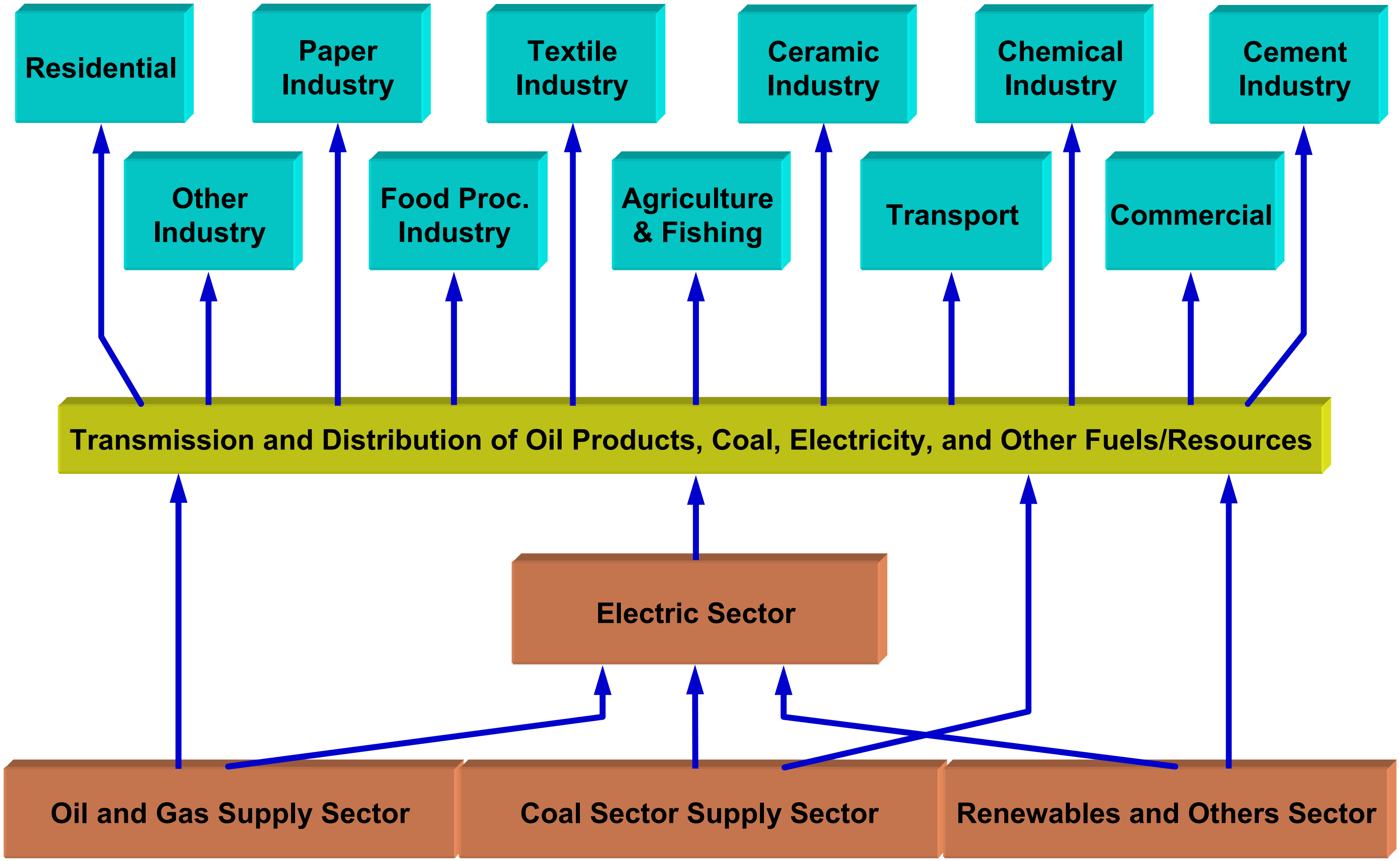
INPUT

- **Energy system structure**
- **Base year energy flows and prices**
- **Energy demand growth projections**
- **Technical and policy constraints**

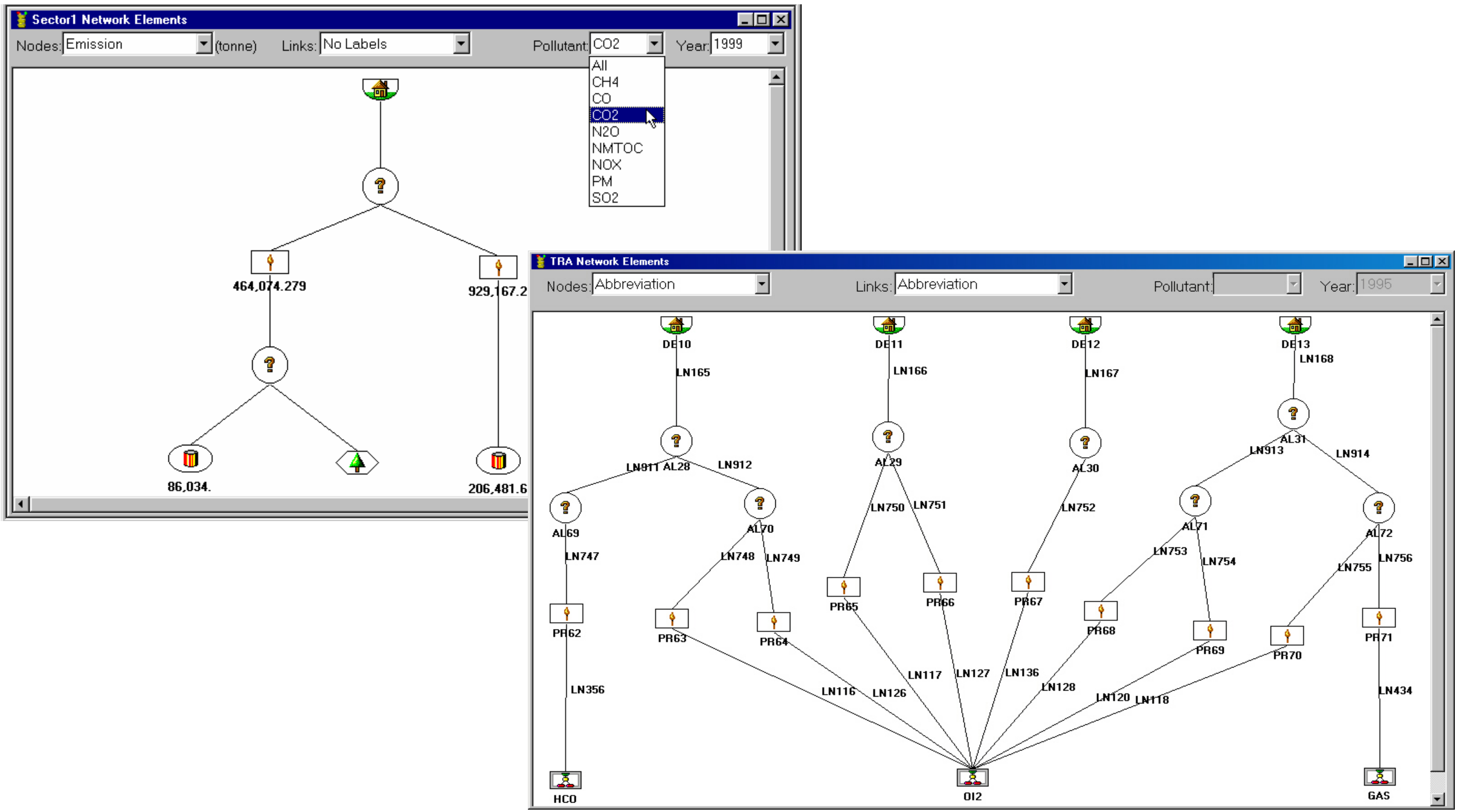
OUTPUT



ENPEP-BALANCE Uses an Energy Network to Simulate Energy Markets

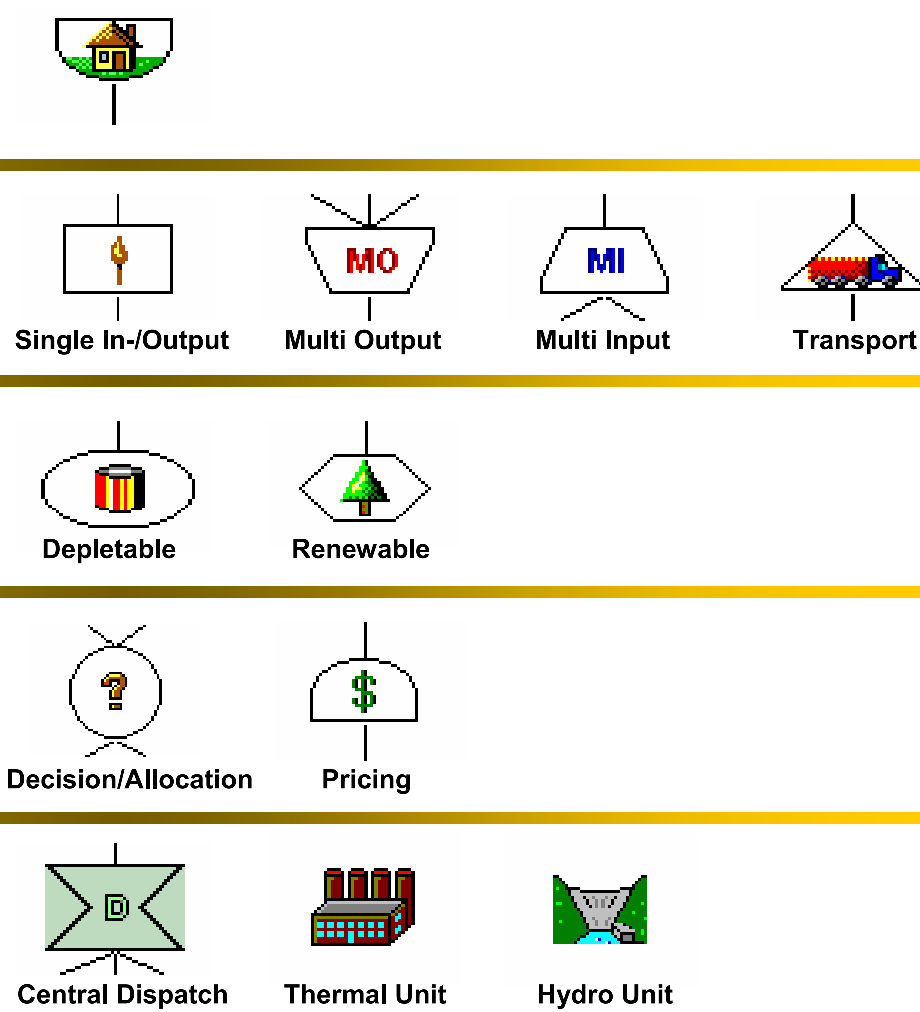


Using Nodes and Links, Each Sector is Modeled Differently Depending on Data Availability and Type of Issue Analyzed

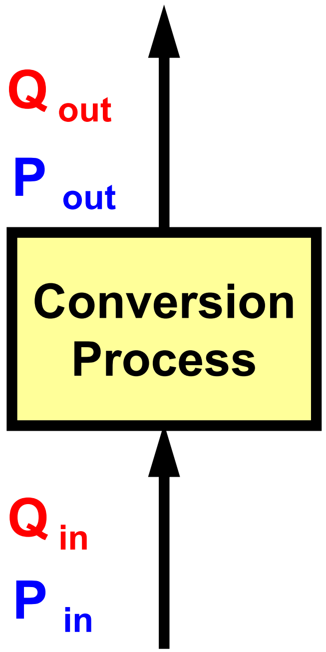


The Following Node Types are Available to Model Different Energy Activities

- Demand
- Conversion Processes
- Resource Processes
- Economic Processes
- Electricity Dispatch and Thermal and Hydro Units



Nodes Are a Series of Simple Sub-Models, Each With a Set of Quantity and Price Equations



- Price $_{output}$ = f (Price $_{input}$)
  - Example conversion process

    Revenue = Cost

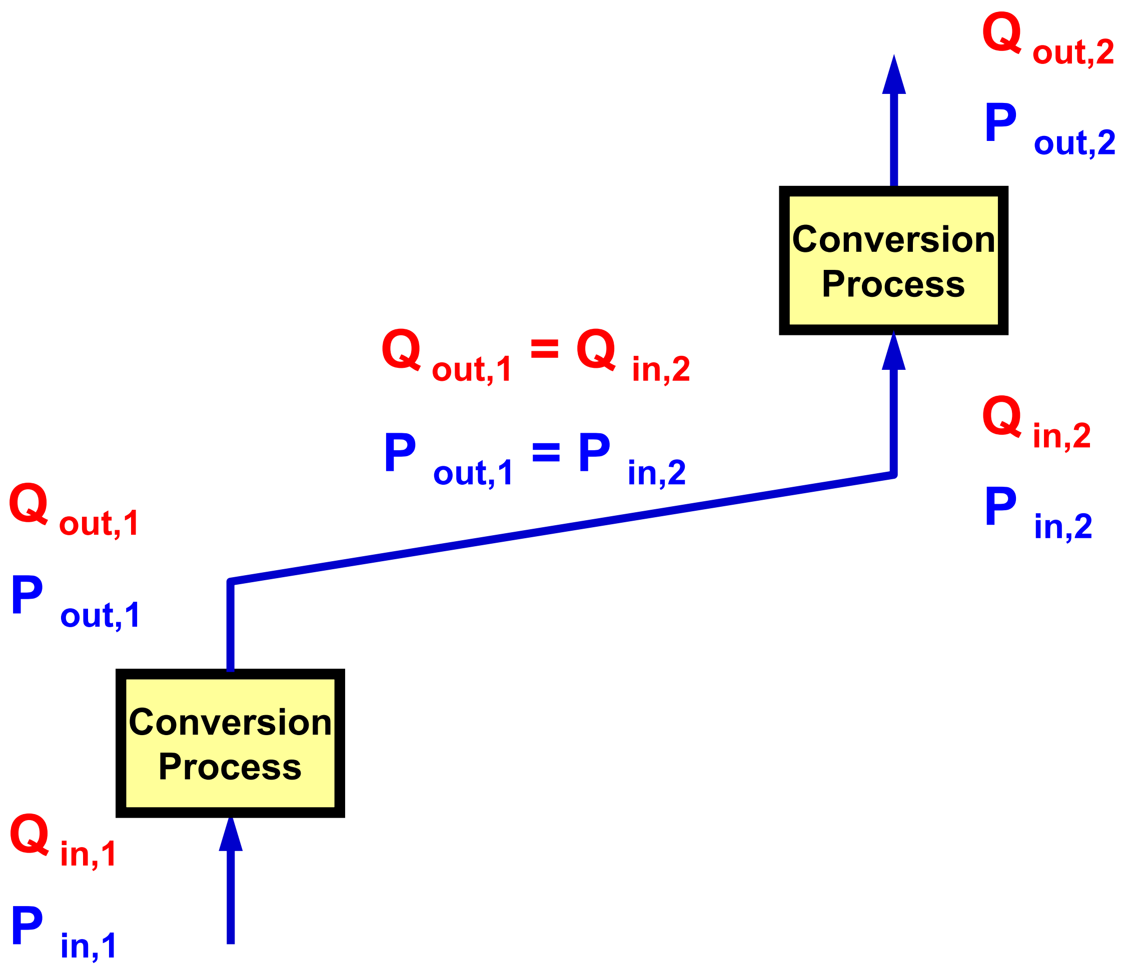
    Q_{out} x P_{out} = Q_{in} x P_{in} + O&M + Capital Recovery

- **Quantity$_{output}$ = f (Quantity$_{input}$)**
  - Example conversion process

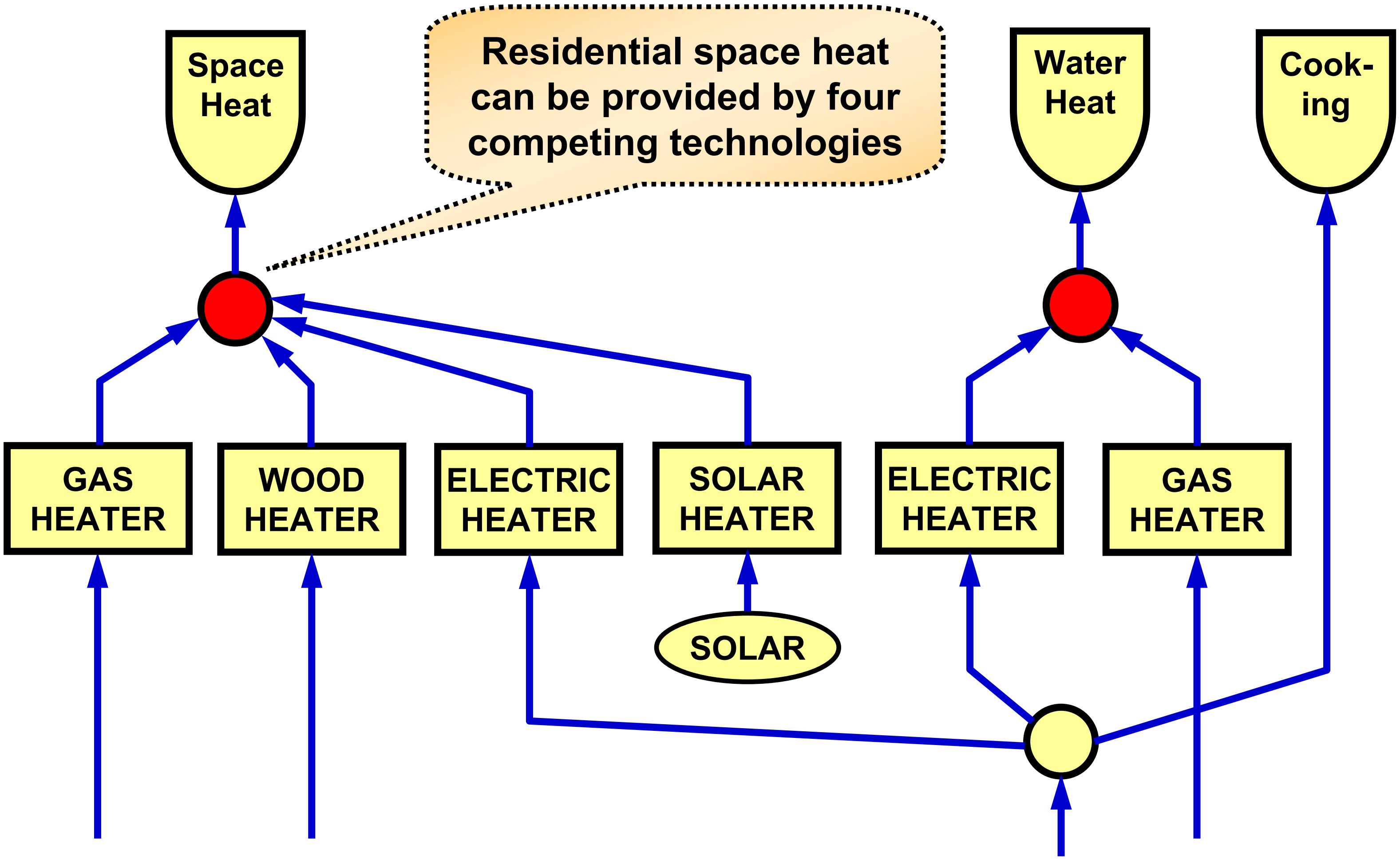
    Q_{out} = Q_{in} x γ

    γ: conversion efficiency

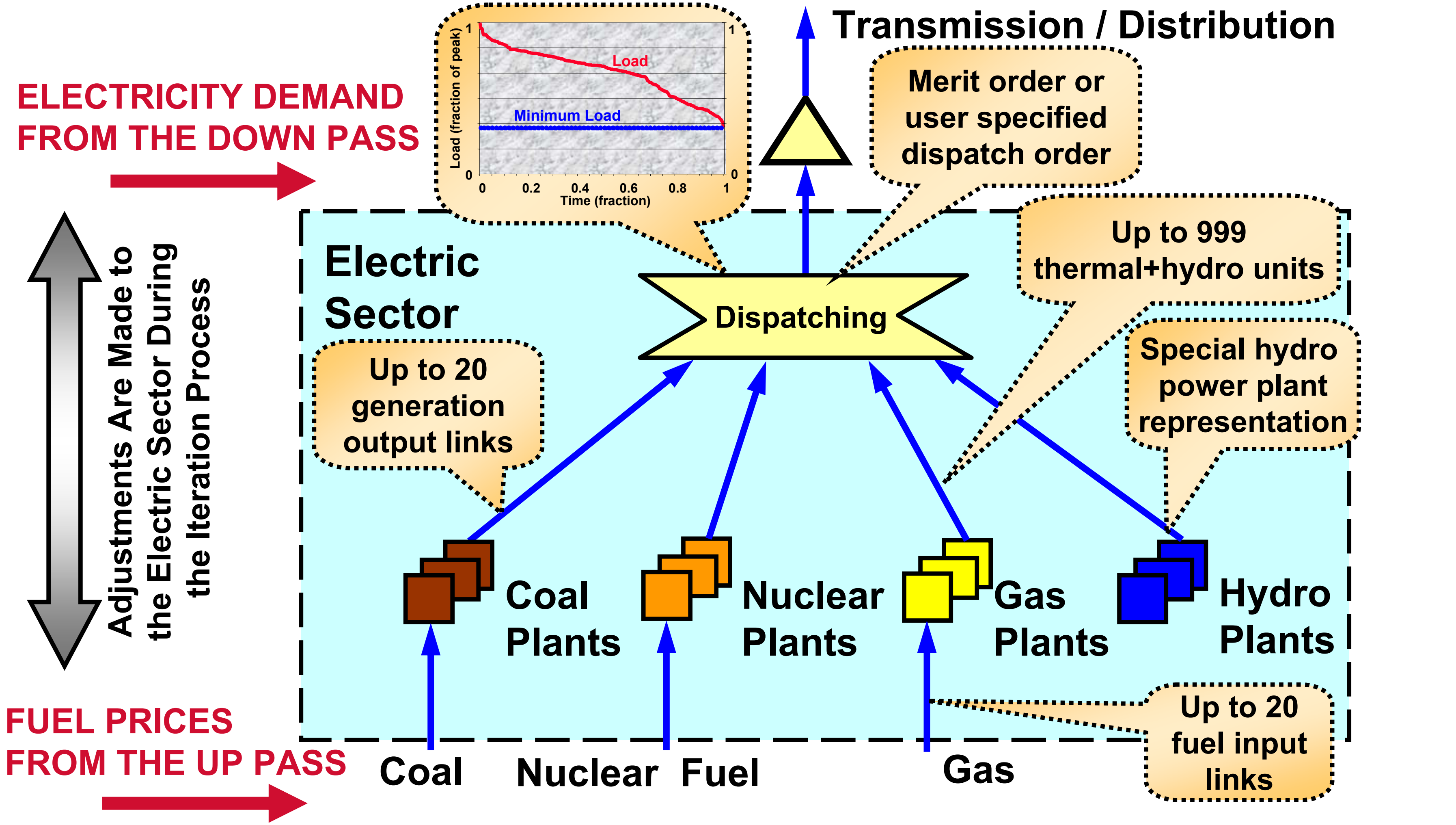
The Links Connect the Nodes and Pass Information from One Node to Another



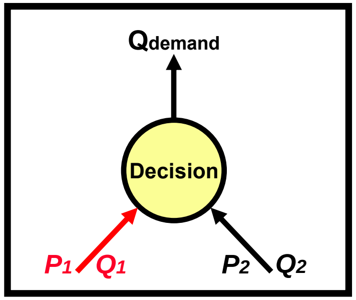
At the Decision Nodes, Fuels and Technologies Compete for Future Market Shares



The Electricity Dispatch Node Handles the Electric Sector in a Special Way



ENPEP-BALANCE Uses a Logit-Function to Estimate Market Shares of Competing Commodities at the Decision Node



$$MS_1 = \frac{Q_1}{Q_1 + Q_2} = \frac{\left[\frac{1}{P_1 \times PM_1}\right]^{\gamma}}{\left[\frac{1}{P_1 \times PM_1}\right]^{\gamma} + \left[\frac{1}{P_2 \times PM_2}\right]^{\gamma}}$$

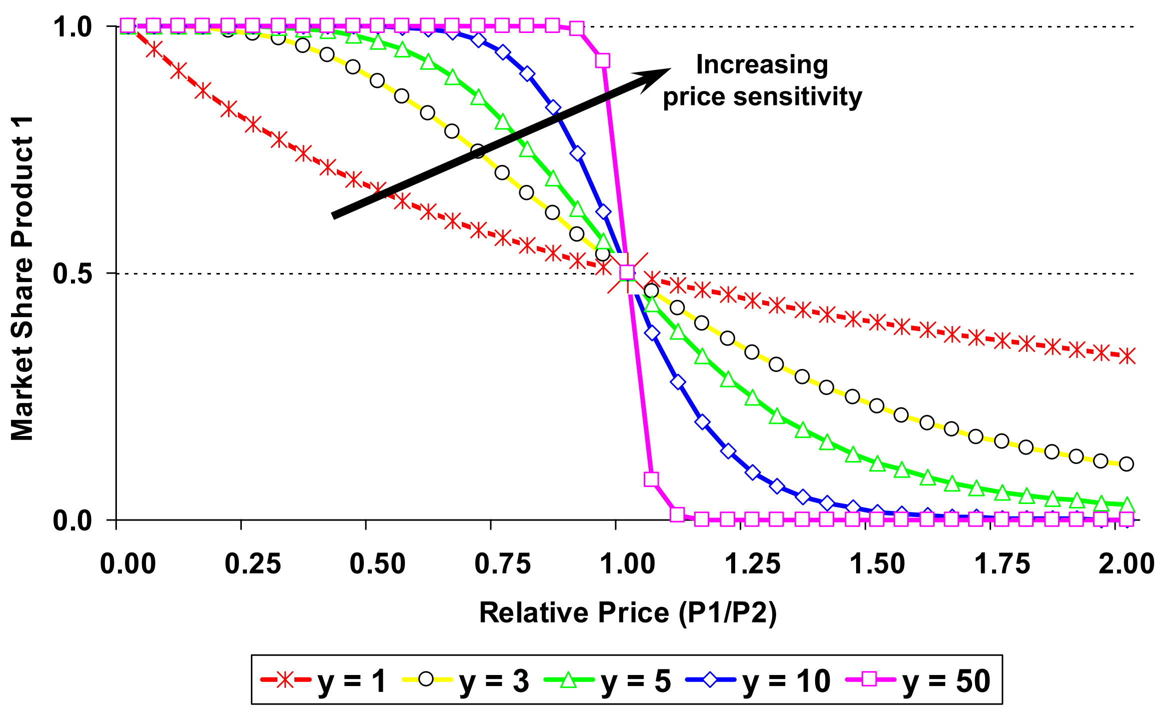
γ price sensitivity for this decision process

MS: market share

P: price

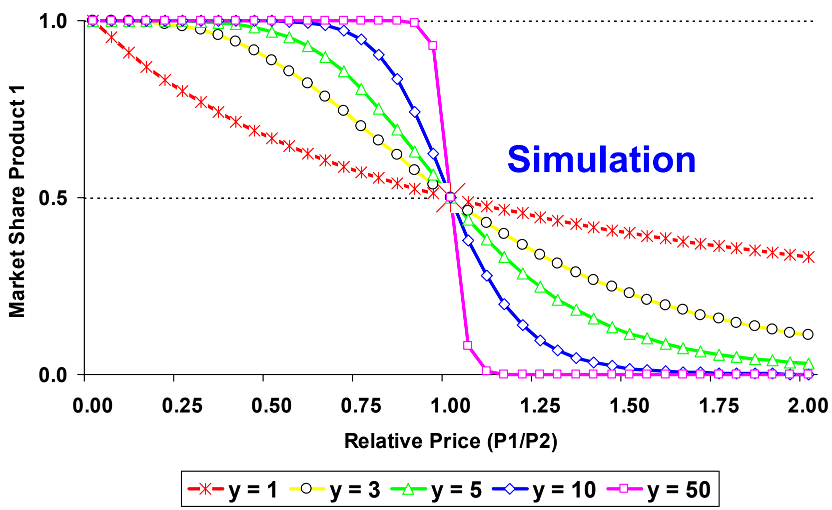
PM: premium multiplier

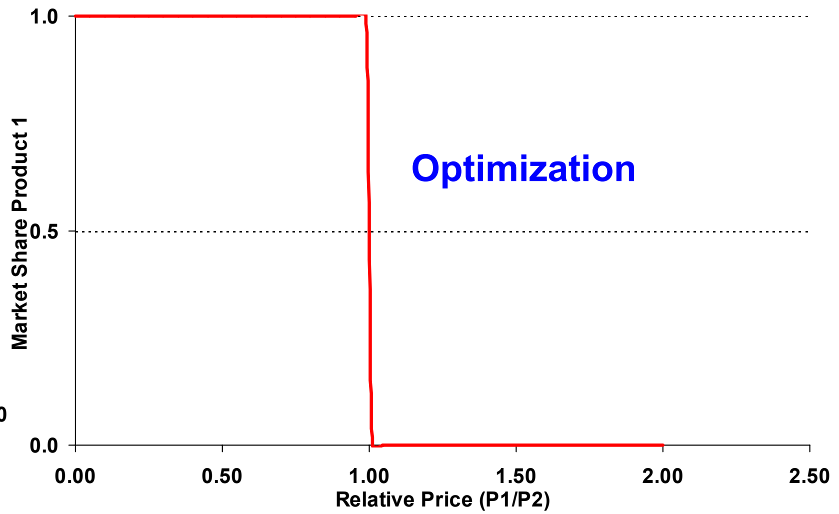
Q: quantity



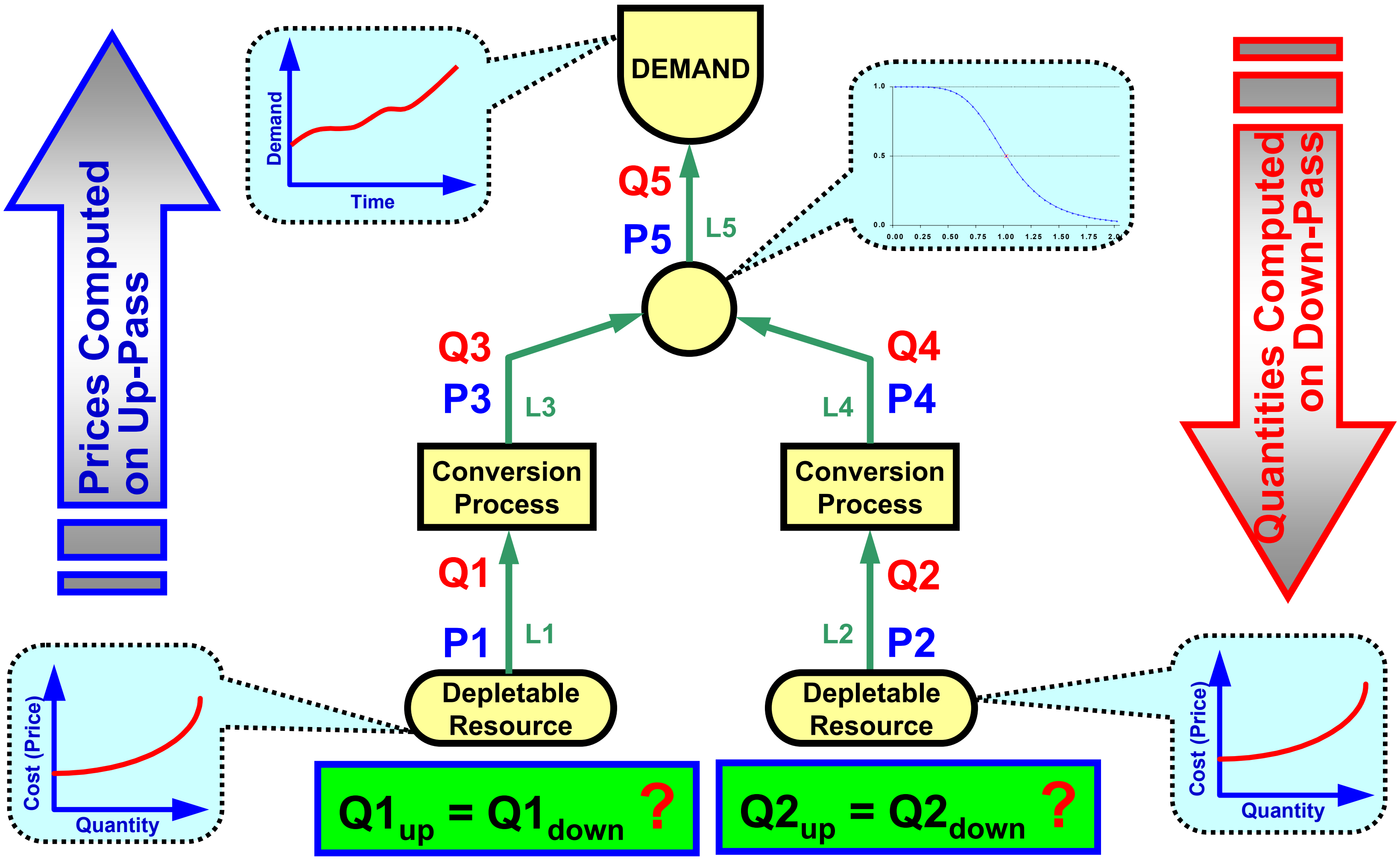
The ENPEP-BALANCE Nonlinear Equilibrium Algorithm is Based on Decentralized Decision Making

- Market share calculation assumes “ideal market” subject to government policies, fuel availability, and market constraints
- A lag factor accounts for delays in capital stock turnover
- The result is a nonlinear, market-based equilibrium solution within policy constraints, not a simple, linear optimization
- No single person or organization controls all energy prices and decisions on energy use
- All decision makers optimize their energy choices based on their own needs and desires





ENPEP-BALANCE Uses an Up/Down Pass Sequence and the Jacobi Iterative Technique to Determine the Market Clearing Prices and Quantities (Market Equilibrium)



The Up-Pass and Down-Pass Tell the Model in Which Sequence to Perform the Calculations (Which Node Comes When)

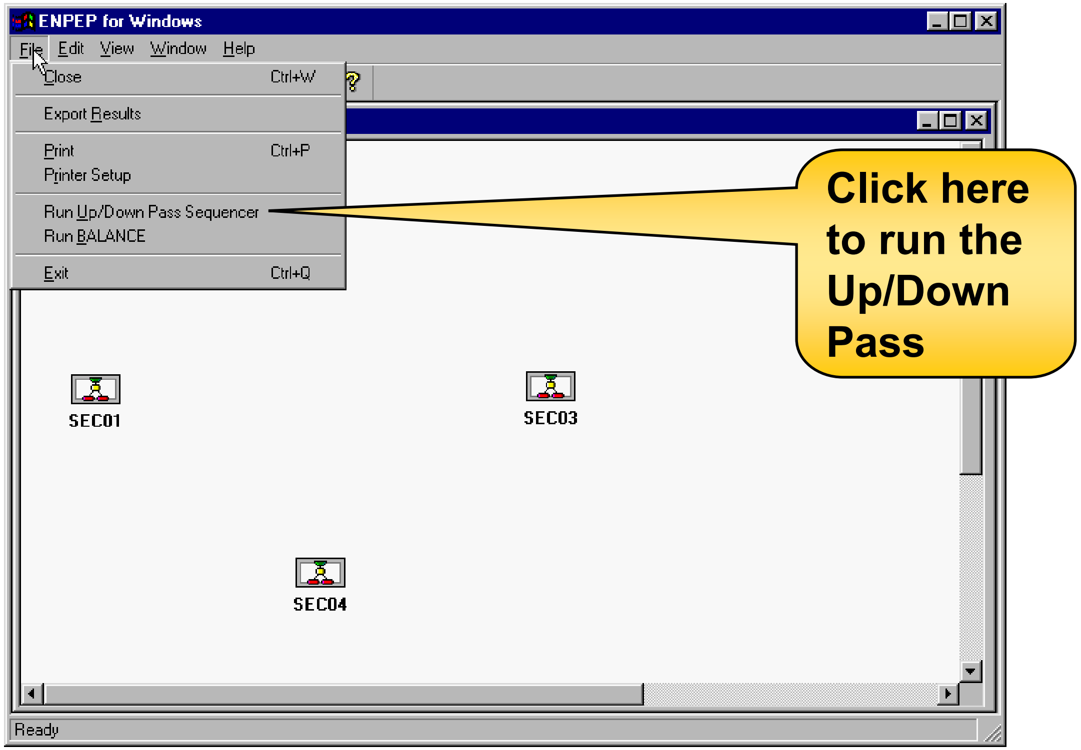
- Up-Pass and Down-Pass Sequences are repeated until convergence is achieved

CONVERGENCE IS ACHIEVED WHEN:

- Q1 (down) = Q1 (up) +/- Tolerance Level
- Q2 (down) = Q2 (up) +/- Tolerance Level
- The final result is a converged solution
- The solution is in equilibrium across the whole network

Execution of the Up and Down-Pass Sequencer in ENPEP-BALANCE

- Run the Up/Down Pass Sequencer before running ENPEP-BALANCE for the first time
- This will determine the "node visitation sequence"
- Later, the Up/Down Pass must be executed only if there has been a **CHANGE IN THE STRUCTURE** of the energy network
  - Add/delete nodes
  - Add/delete links



The Calculated Up/Down Node Visitation Sequence Can Be Viewed in Tabular Form

BDEMO Case Up/Down Sequence

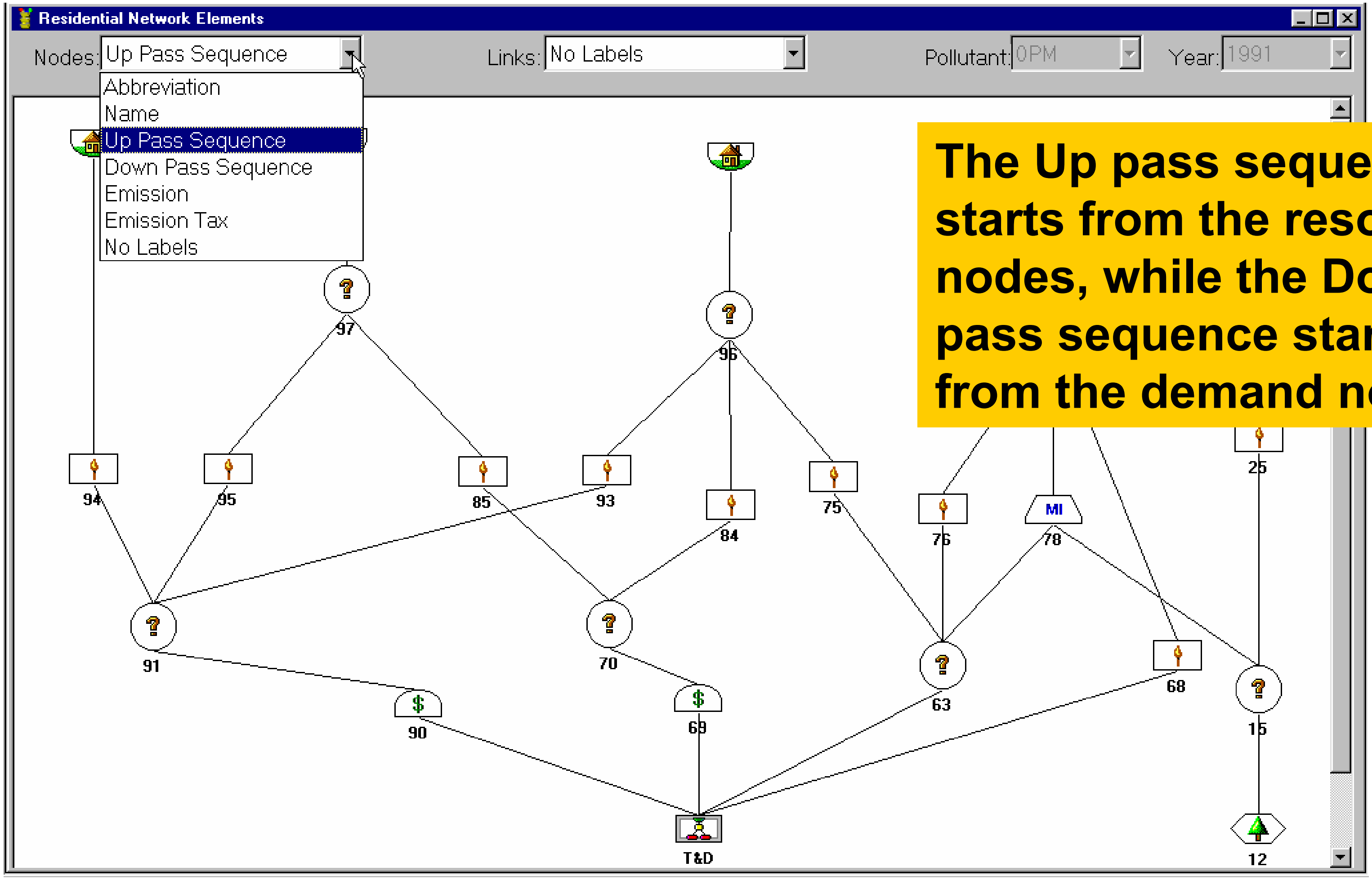
Up Pass Sequence | Down Pass Sequence

Node Type	Node Abbreviation	Node Name	Sector Abbreviation	Sector Name	Up Sequence
RS	I-LPG	LPG Import	SEC01	Sector One	1
RS	I-FO	FOIL Import	SEC01	Sector One	2
RS	I-OIL	I-OIL	SEC01	Sector One	3
RS	FO	Fuel oil	SEC04	Sector 04	4
RS	RS201	Depletable 201	SEC02	Sector 2	5
RS	TUSRC	Thermal Source	SEC03	Sector 3	6
RS	wcoal	Western Sumbit Coal	SEC03	Sector 3	7
RS	NGAS1	Natural Gas Node 1	SEC01	Sector One	8
RS	OIL1	Oil Node 1	SEC01	Sector One	9
RS	DMOIL	Domestic Oil	SEC01	Sector One	10
RN	ETH	Ethanol	SEC01	Sector One	11
RN	SOLAR	Solar	SEC01	Sector One	12
AL	ALOC1	Alloc. Node One	SEC01	Sector One	13
AL	ALOC4	Alloc. Node Four	SEC01	Sector One	14

OK | Cancel

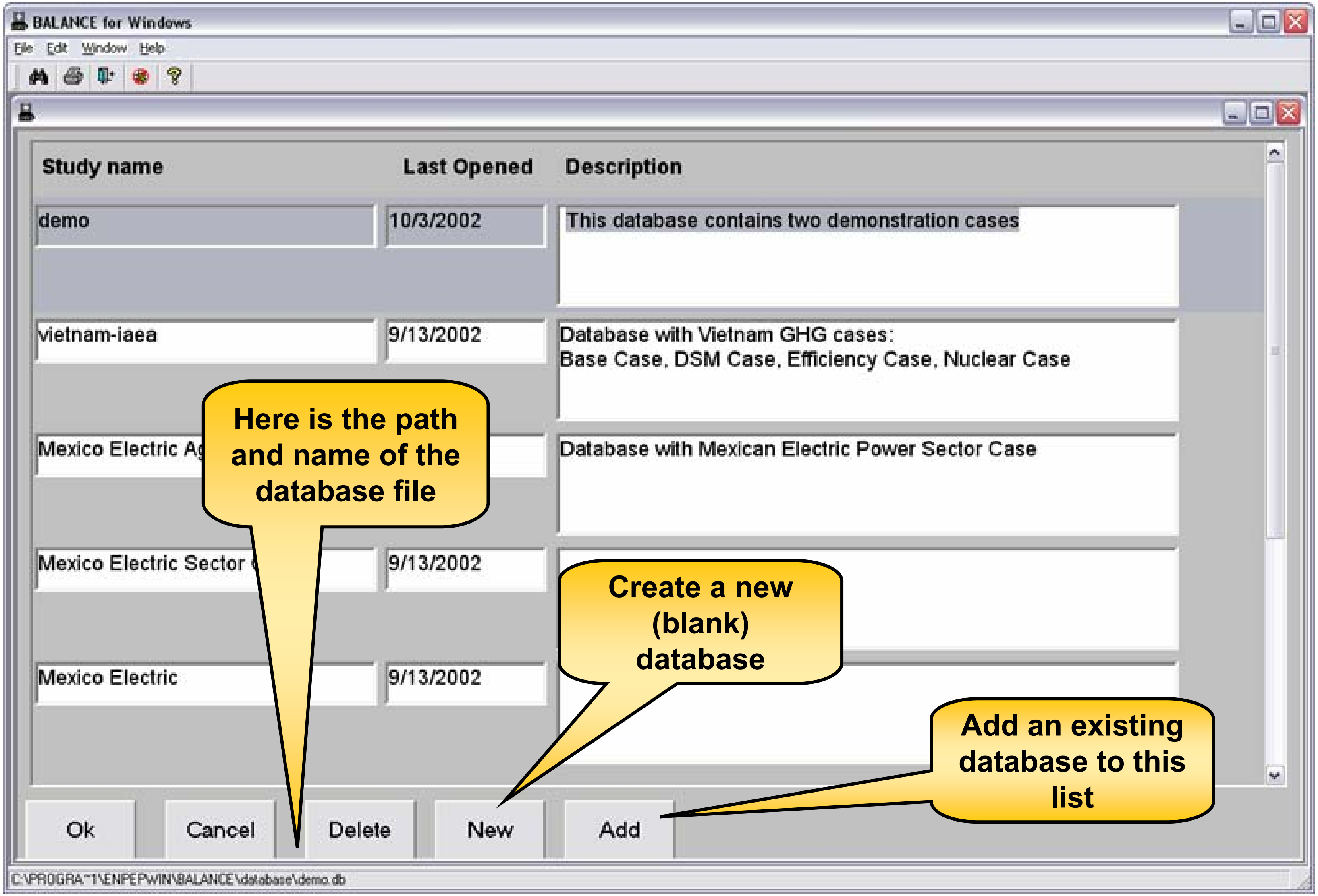
This screen also allows the user to manually adjust the node visitation sequence, if necessary.

The Up/Down Node Visitation Sequence Can Be Viewed Directly in the Network

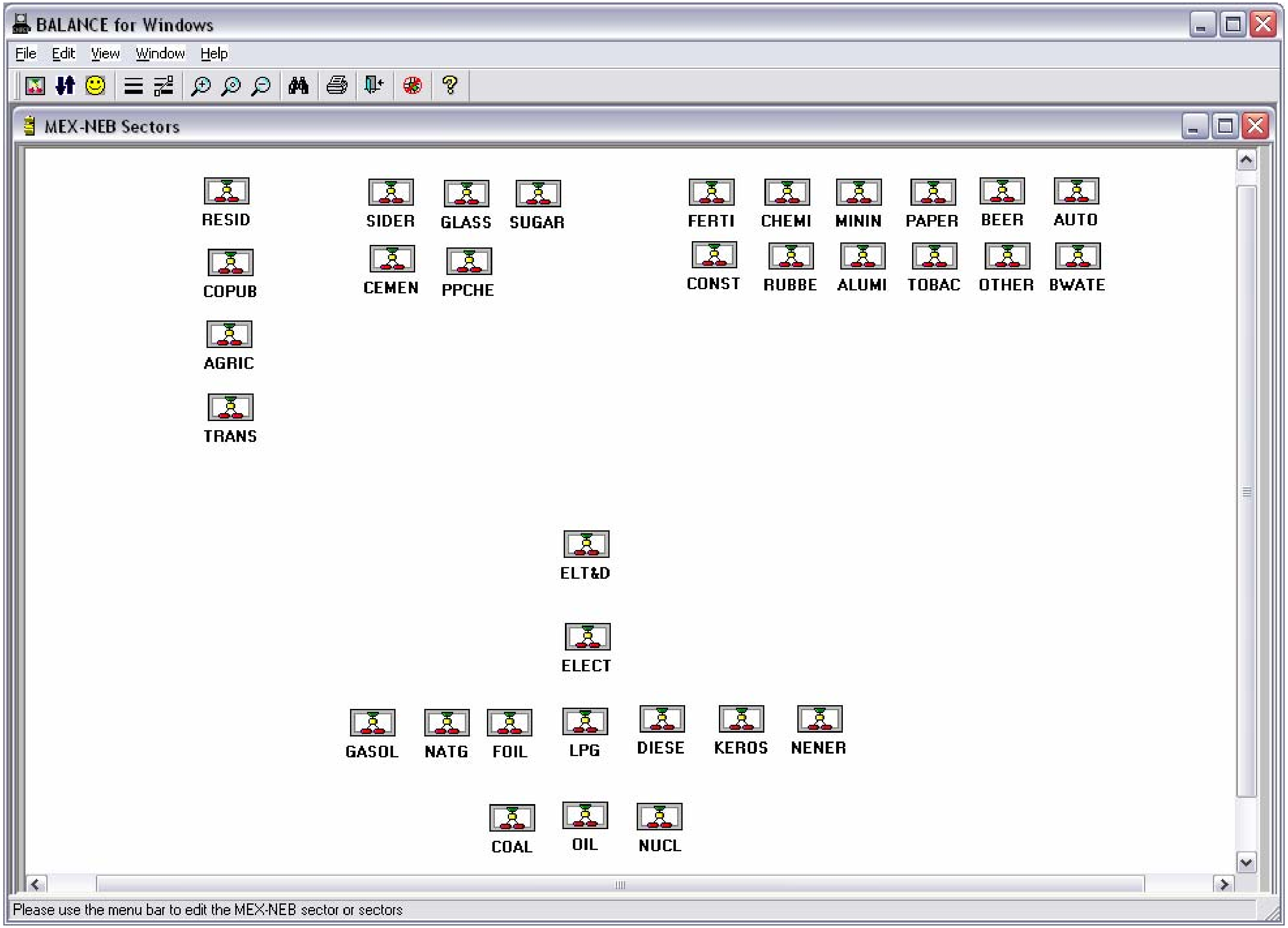


The Up pass sequence starts from the resource nodes, while the Down pass sequence starts from the demand nodes.

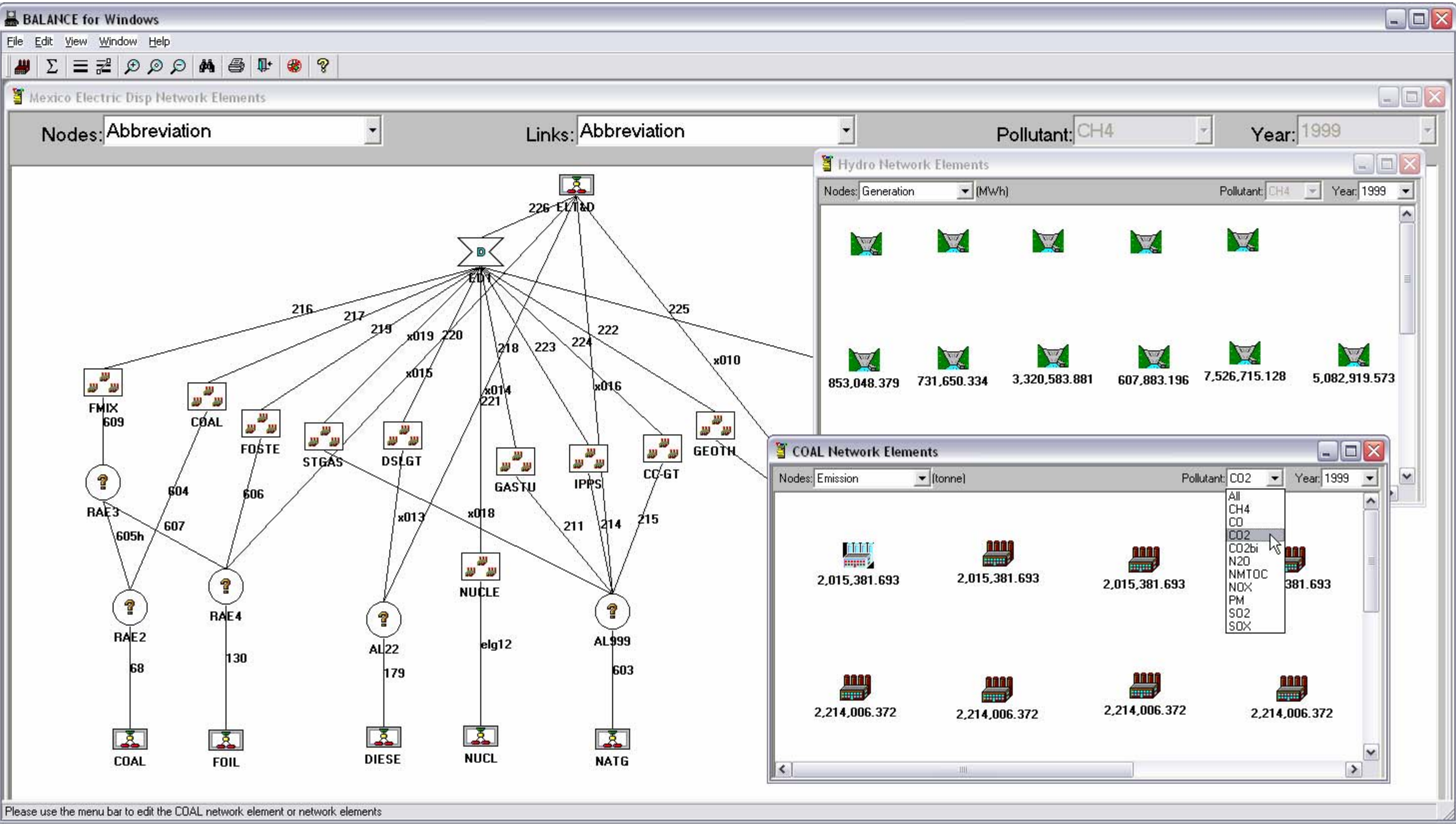
Each Case Study Can be Stored in a Different Database



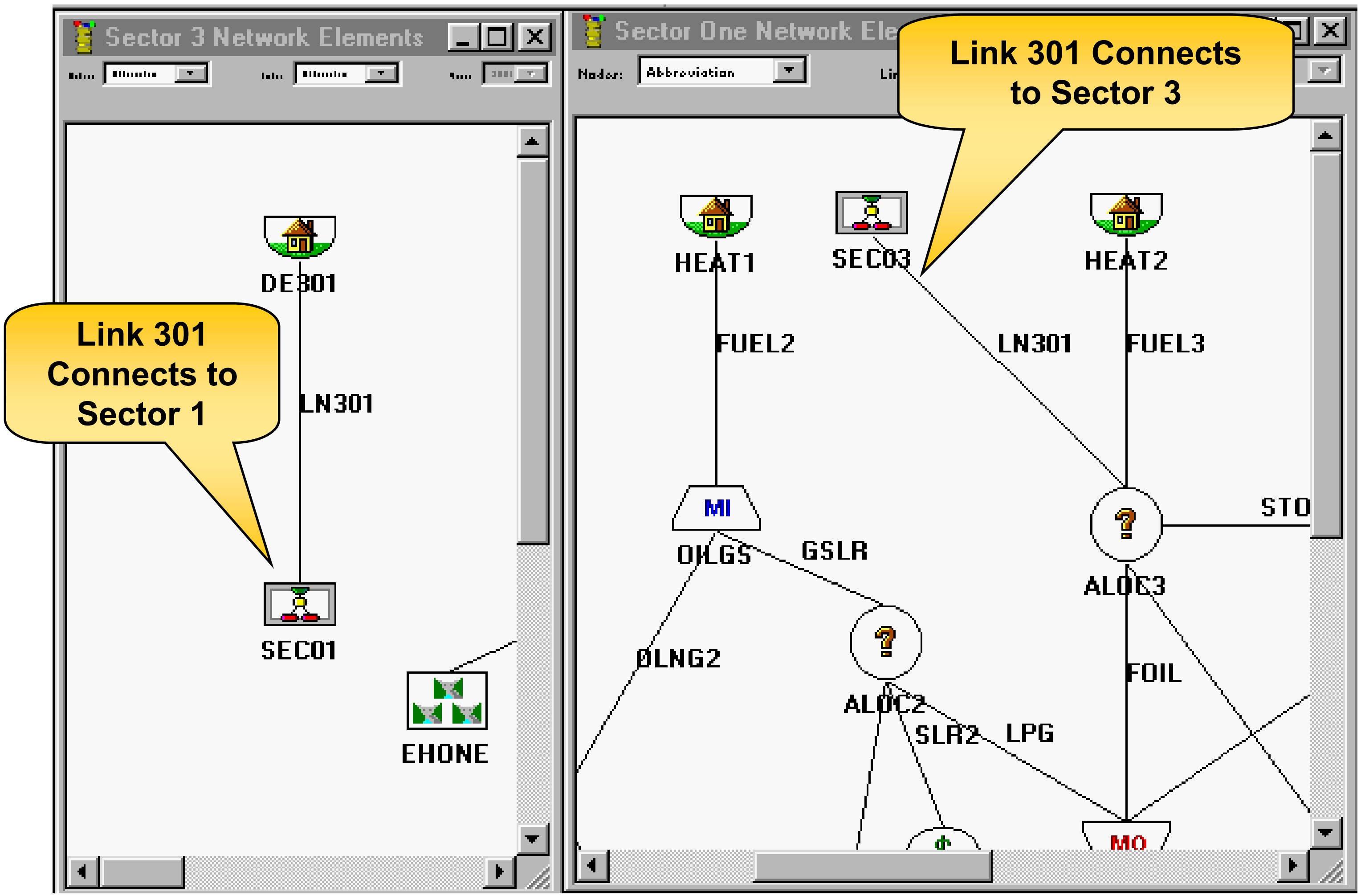
The First Step in Developing an ENPEP-BALANCE Network is to Define the Sectors Included in Your System



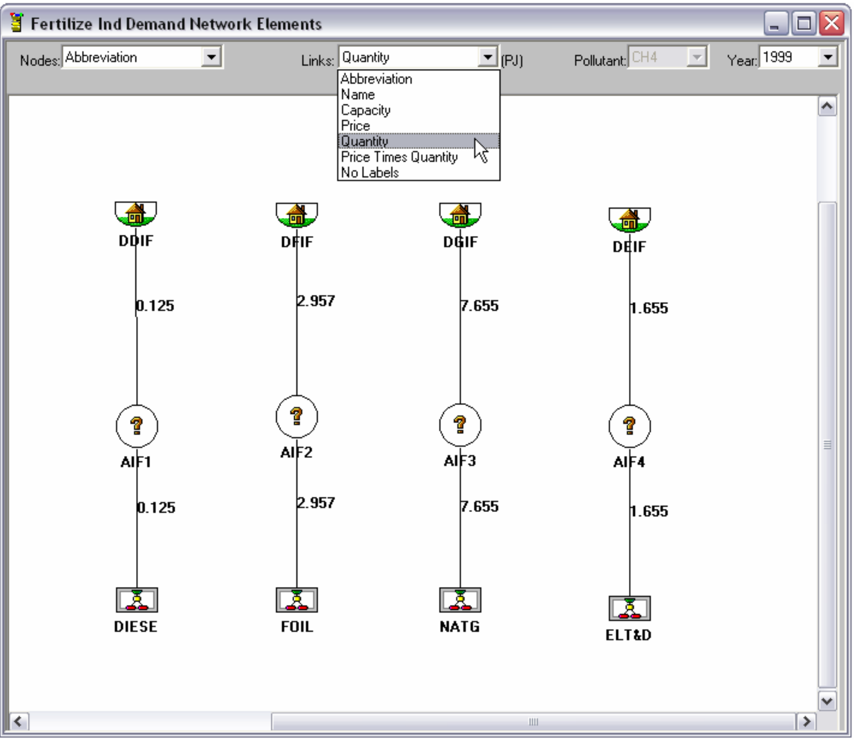
Each Sector May be Modeled Differently Depending on Data Availability and Type of Issue Analyzed: Power Sector Can Be Modeled at the Unit Level

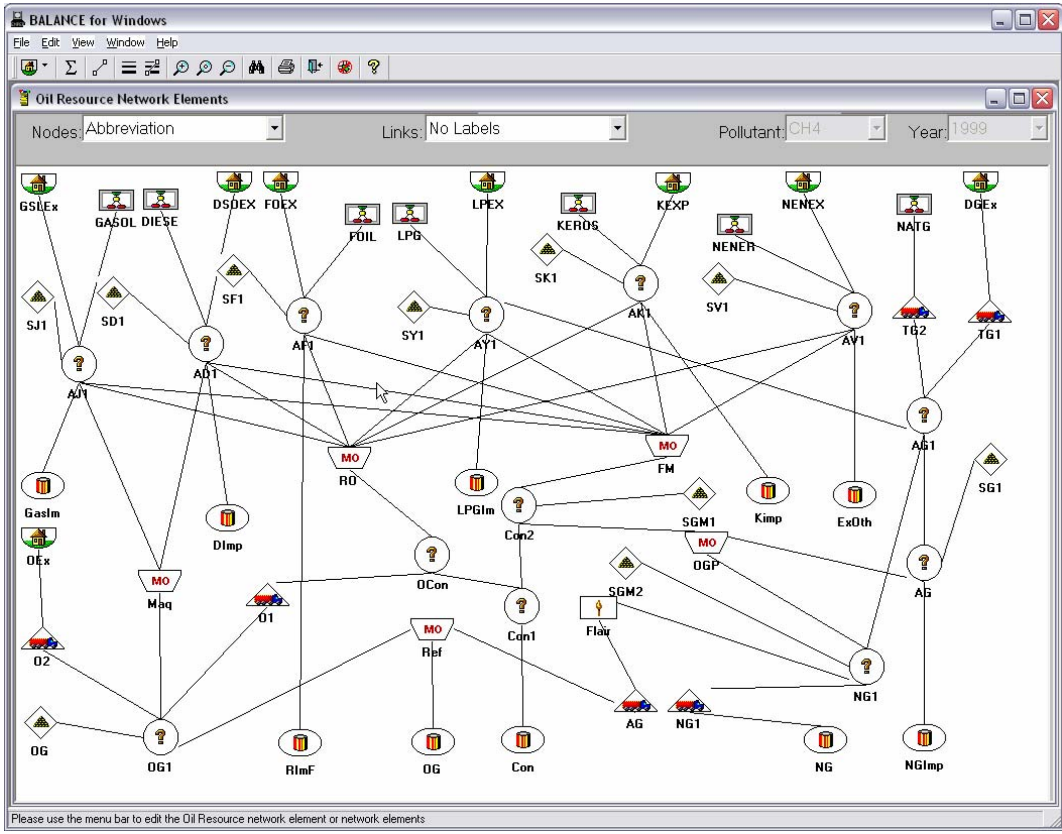


Intersectoral Links Can Connect Energy Networks of Different Sectors

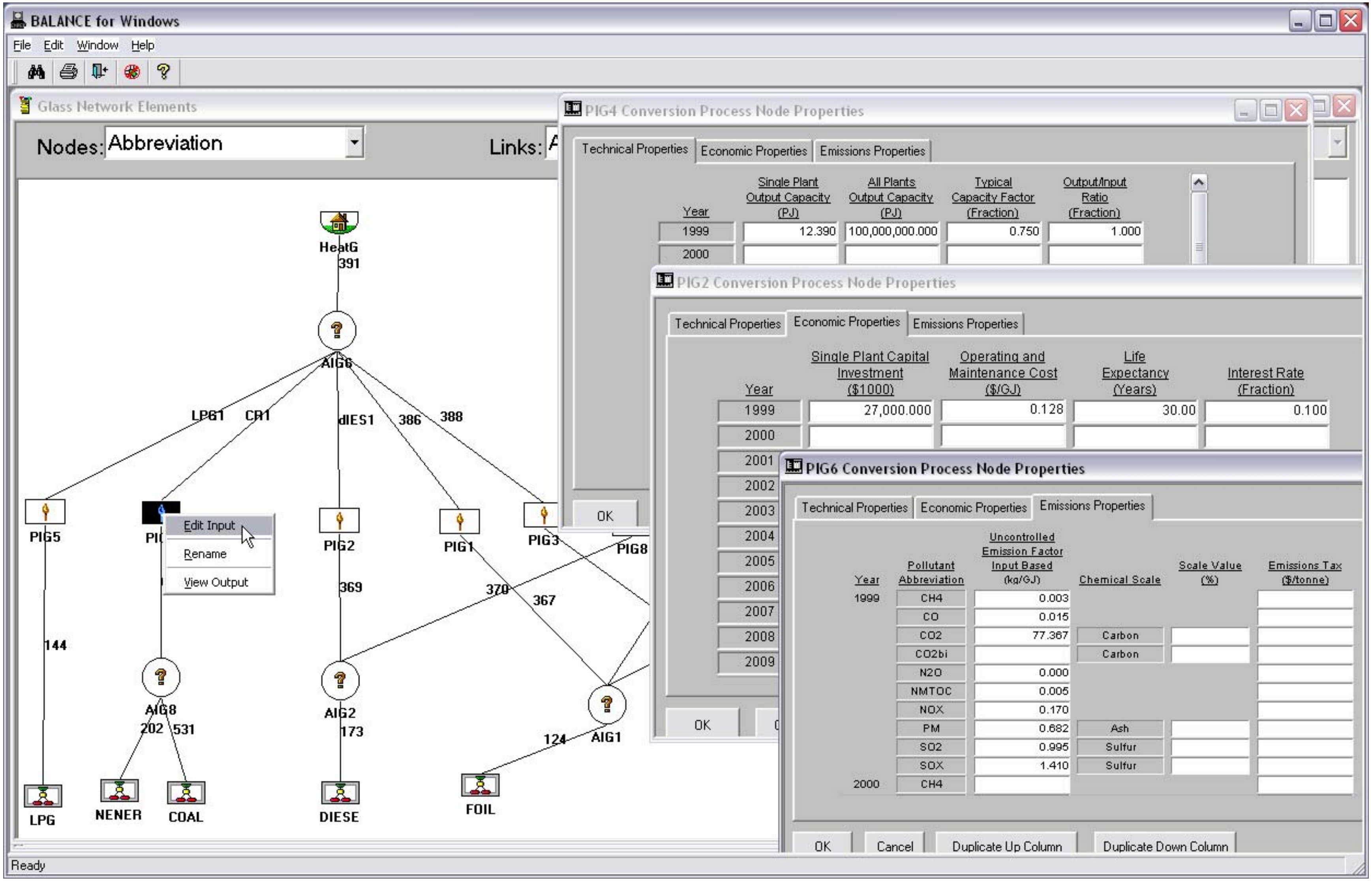


The Level of Detail May Vary from Simple to Complex:
Example: Simple Fertilizer Industry and More Complex Oil & Gas Sector

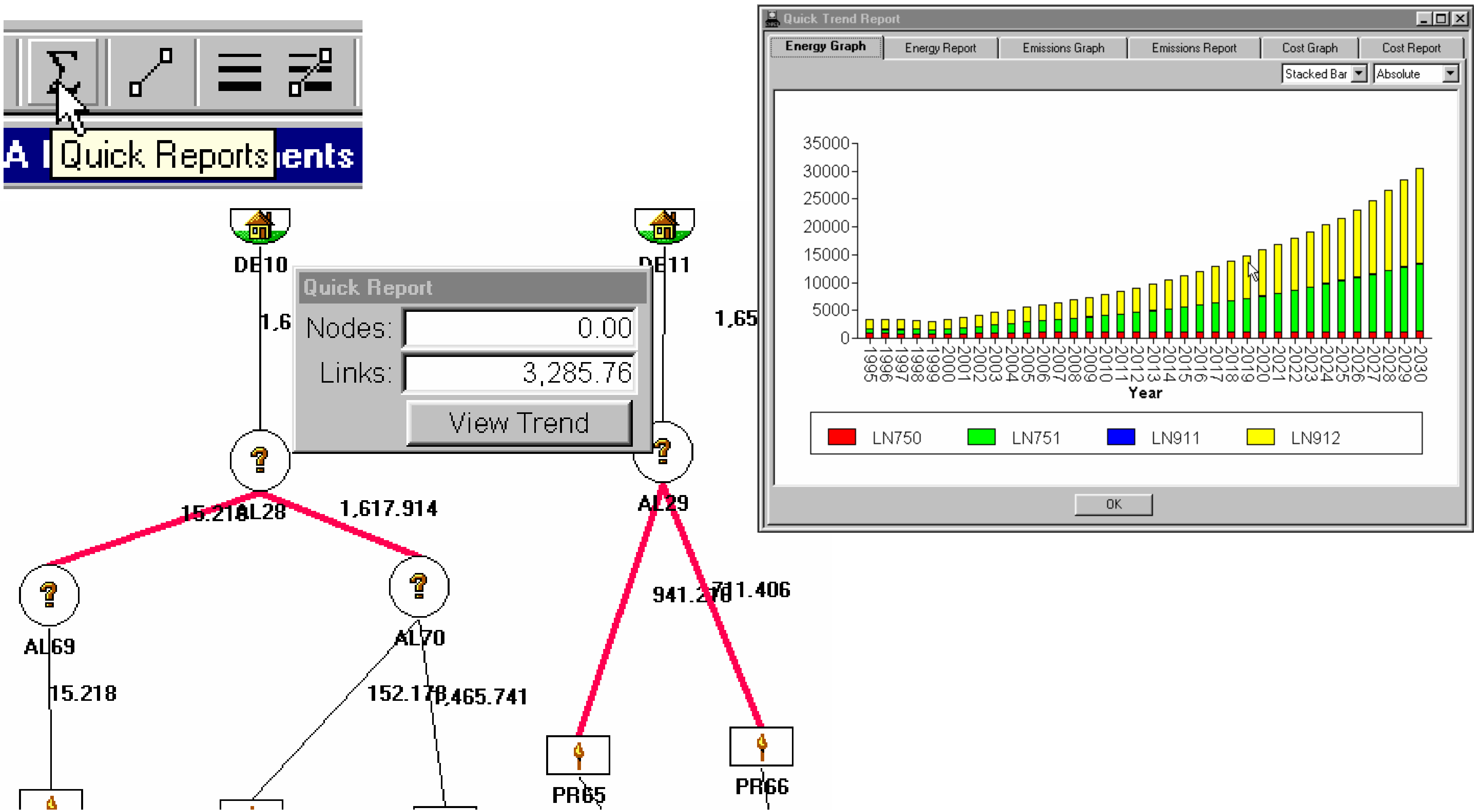




All Network Elements in ENPEP-BALANCE Can Be Accessed Using a Standardized Simple Menu



Results Can be Viewed Interactively for Individual Network Components and the Entire System

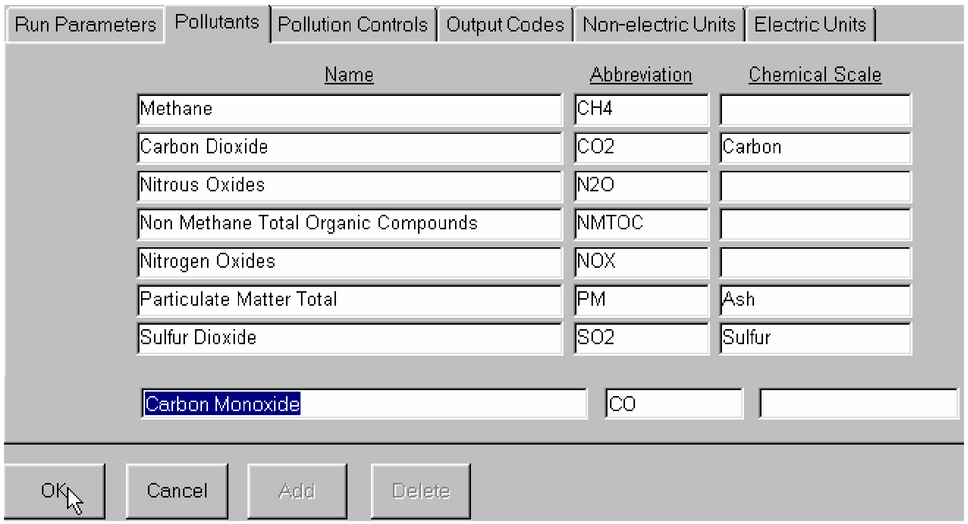


ENPEP-BALANCE Uses a Standard Methodology to Determine the Uncontrolled and Controlled Source Emissions

Uncontrolled Emissions = Fuel Consumption x Emission Factor x Chemical Scale

Controlled Emissions = Uncontrolled Emissions x (100 - Control Efficiency) / 100

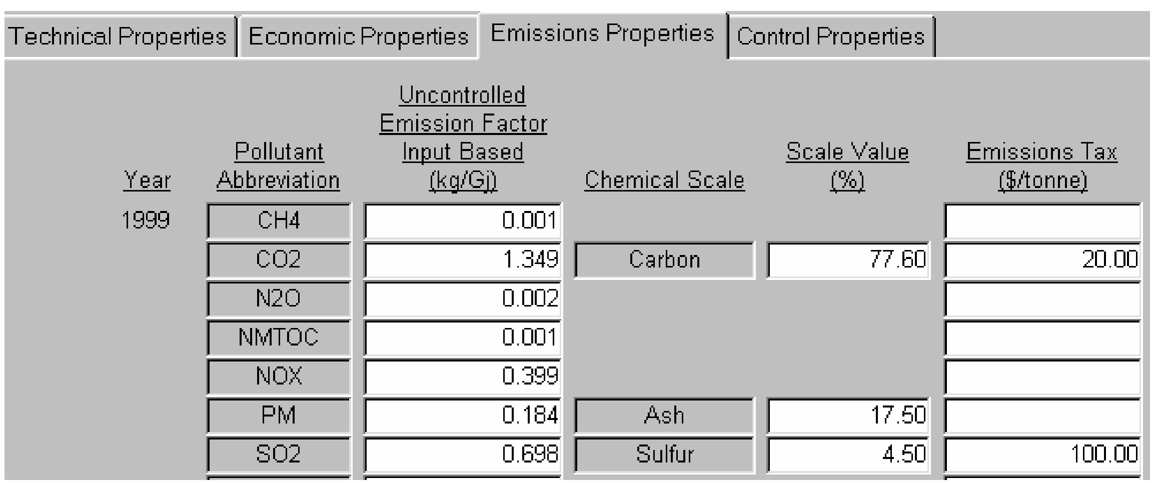
Emissions Are Calculated and Reported by Node for any Pollutant the User Specifies



Run Parameters | Pollutants | Pollution Controls | Output Codes | Non-electric Units | Electric Units

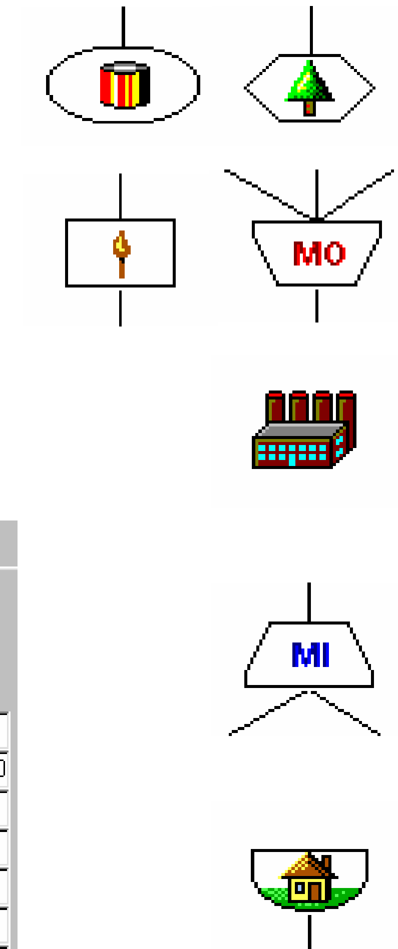
Name	Abbreviation	Chemical Scale
Methane	CH4	
Carbon Dioxide	CO2	Carbon
Nitrous Oxides	N2O	
Non Methane Total Organic Compounds	NMTOC	
Nitrogen Oxides	NOX	
Particulate Matter Total	PM	Ash
Sulfur Dioxide	SO2	Sulfur
Carbon Monoxide	CO	

OK | Cancel | Add | Delete

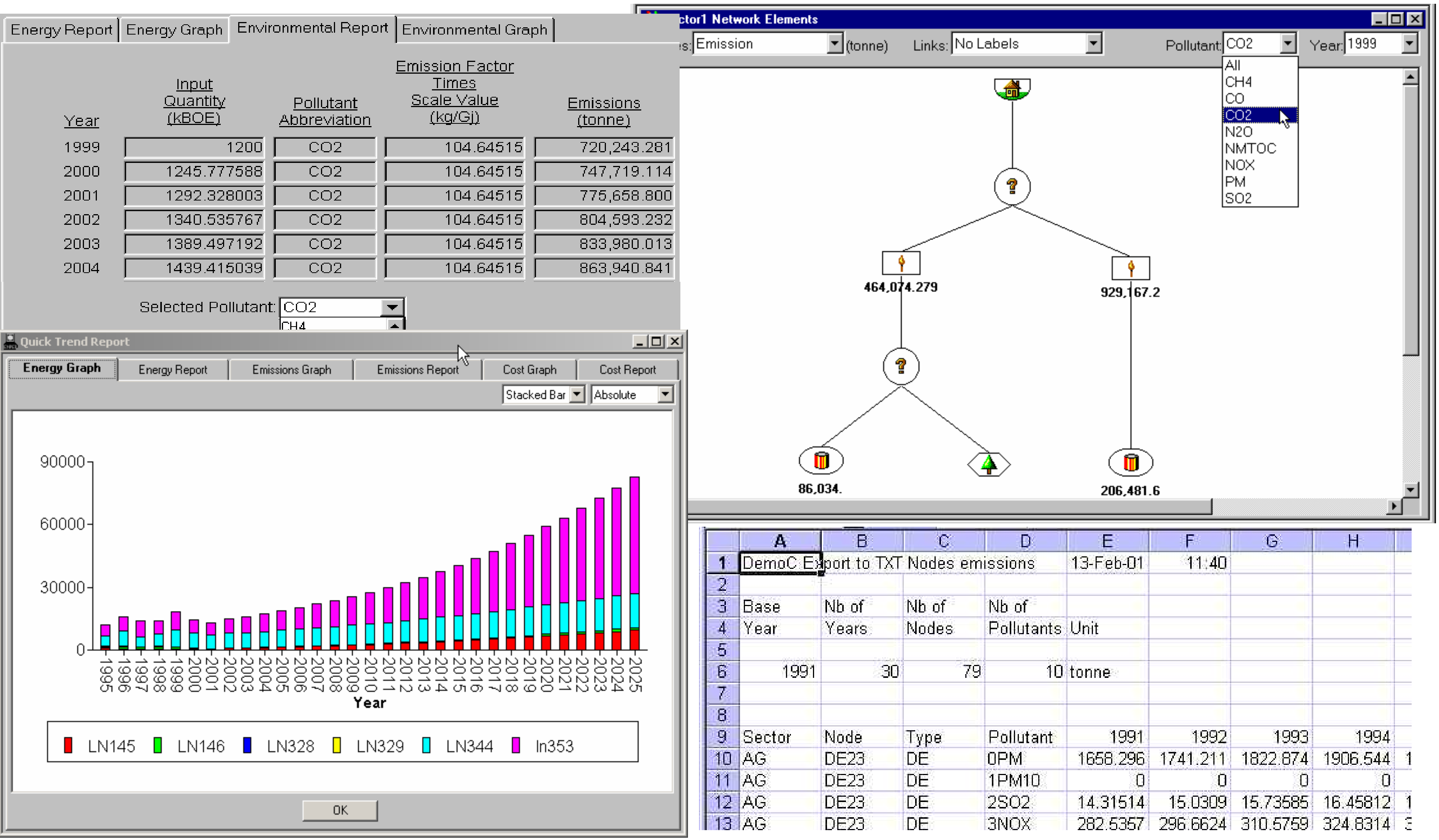


Technical Properties | Economic Properties | Emissions Properties | Control Properties

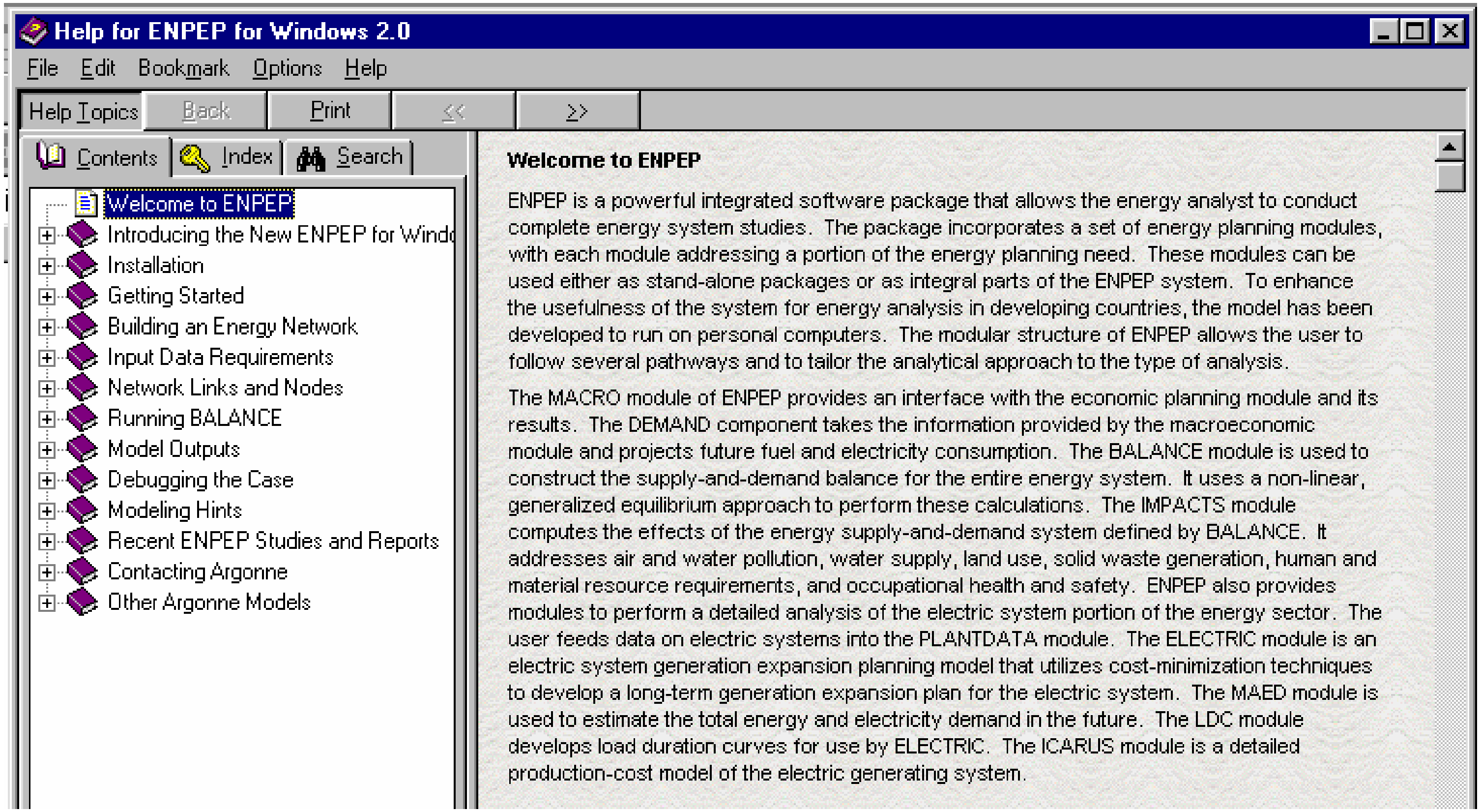
Year	Pollutant Abbreviation	Uncontrolled Emission Factor Input Based (kg/Gj)	Chemical Scale	Scale Value (%)	Emissions Tax ($/tonne)
1999	CH4	0.001			
	CO2	1.349	Carbon	77.60	20.00
	N2O	0.002			
	NMTOC	0.001			
	NOX	0.399			
	PM	0.184	Ash	17.50	
	SO2	0.698	Sulfur	4.50	100.00



Environmental Results Can be Viewed Directly in the Network, in Tables, Simple Graphs, or Exported to EXCEL



A Help System is Available to Provide Online Support

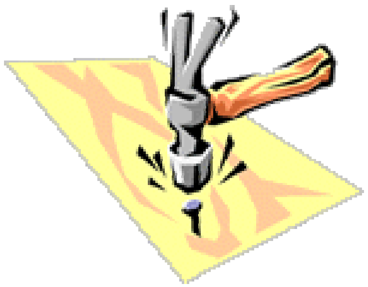


Note: The help system is still under construction. Content will change and not all topics may be available at this time.

Energy System Modeling in ENPEP-BALANCE: Model Limitations

As with all models, ENPEP-BALANCE has its limitations:

- The market share formula needs to be applied carefully to produce realistic results (particularly from transition from 1st to 2nd year)
- The solution is generated year-by-year and is said to be “myopic”
  - However, in today’s short-term oriented energy market, this may actually be an advantage
- It is demand-driven
- If not set up in sufficient detail, it can be insensitive to price
- The ease of use in the WINDOWS interface conceals the sub-models!
- Nevertheless, the ENPEP-BALANCE approach is proved to be powerful and useful if applied correctly;
- ENPEP-BALANCE is a tool - and a tool should be used wisely



ENPEP-BALANCE is Used by Energy and Environmental Experts Worldwide to Analyze a Variety of Critical Issues

- Electric system analysis
  - expansion analysis, demand side management
  - optimal hydro/thermal dispatch ($, environment)
  - deregulation, independent power producers, power market studies, interconnection studies, etc.

- Total energy system
  - overall energy sector development strategies
  - natural gas market analysis
  - energy conservation+efficiency

- Environmental analysis
  - emissions projections for PM, SO_2, NO_X, etc.
  - emissions reduction strategies for PM, SO_2 and NO_X
  - emissions trading for SO_2 and CO_2 (cap and trade)
  - GHG mitigation studies and Kyoto Mechanisms
  - waste generation, land use, water pollution

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Information on ENPEP-BALANCE Applications is Available on our Website